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Influence of Foliar Application of Boron and Plant Growth Regulators on Hybrid Seed Yield and Quality of Bitter Gourd (*Momordica charantia* L.) under Protected Cultivation

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Abstract

A field experiment was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Raichur during the *rabi* season of 2017-18, to study the influence of foliar application of boron and plant growth regulators on hybrid seed yield and quality of bitter gourd under protected cultivation, which was laid in a randomized block design with three replications. The experiment consisted of seven treatments involving five growth regulators in combination with micronutrient Boron *viz*., T_1- control, T_2- boron (1 g/l), T_3- boron (1 g/l) + GA_3 (50 ppm), T_4- boron (1 g/l) + NAA (0.3 ml/l), T_5- Boron (1g/l) + triacontanol (1.5 ml/l), T_6- Boron (1 g/l) + homobrassinolide (0.5 ml/l), T_7- Boron (1g/l) + humic acid (2%) were sprayed at three different stages *viz.,* two to three leaf stage, peak flowering and fruit initiation. The results revealed that among various treatments the foliar application of (T_6) boron (1 g/l) with homobrassiolide (0.5 ml/l) recorded significantly higher fruit length, fruit diameter, fruit weight, number of fruits per plant, number of seeds per fruit, seed weight per fruit, 100 seed weight, hybrid seed yield per plant and hectare and higher monetary results with higher seed quality parameters like seed germination, shoot length, root length, seedling dry weight, seedling vigour index-I and dehydrogenase enzyme activity and the maximum vine length was recorded by (T_3) boron (1 g/l) + GA_3 (50 ppm) and the control recorded significantly lower parameters. Benefit cost ratio for T_6 was highest (3.08) as compared to control (2.51) in seed production of Bitter Gourd.

Keywords: Plant growth regulators, Bitter gourd, Foliar application and Hybrid seed yield

Agriculture plays an important role in the overall economic development of country where the vegetable sector alone contributes 2.20 per cent to the country's gross domestic product. Substantial increase in yield and quality of vegetable crops depend upon a number of factors. The input like fertilizers, irrigation and plant protection measures and suitable agronomic practices contribute greatly towards enhancing yield and quality of the produce. If good quality seed is not used, the full benefit of such inputs and agronomic practices cannot be realised. The cost of seed represents a mere fraction (2-3%) of the total cost of production, but the quality of seed plays a decisive role in influencing the grower's profitability. Quality seeds, therefore, is the basic critical input upon which all other inputs will depend for their full effectiveness.

Bitter gourd (*Momordica charantia* L.) belongs to family Cucurbitaceae, is one of the most important vegetable crops which can be cultivated all round the year. It is also known as balsam pear, karela or bitter melon which is a fast growing tropical vegetable. In India, it is cultivated in an area of 930 lakh hectare with a production of 1,053 metric tonnes and the productivity of 11.33 tonnes per hectare. In Karnataka, it is cultivated in an area of 1,872 hectare with a production of 13,676 tonnes and productivity of 7.0 tonnes per hectare (Anon., 2016).

Under protected condition many vegetable crops especially cucurbits can be grown round the year with high quality fruit and minimum incidence of disease and pest because it achieved efficiently high water and nutrients. It also helps to increase the photosynthetic efficiency and reduces the transpiration losses.

Boron is an important micronutrient required for pollen germination, pollen tube formation, for better fruit set it also regulates plant metabolism of carbohydrates. It is non-mobile in plants and a continuous supply is necessary at all growing points. The plant growth regulators (PGR's) are considered as a new generation agro chemicals have key role in certain changes in metabolism of fruit and seed growth as a result of which there would be better accumulation of food reserves resulting in higher seed yield. With this back ground in view, an experiment on the 'Influence of foliar application of boron and plant growth regulators on hybrid seed yield and quality of bitter gourd (*Momordica charantia* L.) under protected cultivation' was undertaken.

MATERIAL AND METHODS

The present investigation was carried out at Main Agricultural Research Station, University of Agricultural Sciences, Raichur during the year 2017-18 under protected condition. The experiment was conducted on black clay loam soil with 7.2 pH. The experiment consisted of seven treatments *viz.,* T_1- control, T_2- boron (1 g/l), T_3- boron (1 g/l) + GA_3 (50 ppm), T_4- boron (1 g/l) + NAA (0.3ml/l), T_5- Boron (1g/l) + triacontanol (1.5ml/l), T_6- Boron (1g/l) + homobrassinolide (0.5 ml/l), T_7- Boron (1g/l) + humic acid (2%) which were sprayed once in three different stages *viz.,* two to three leaf stage (before crossing), peak flowering (at the time of crossing) and fruit initiation (after crossing). The experiment was laid under protected cultivation in a randomized block design with three replications. The healthy and bold seeds of both male and female parents of hybrid (MBTH 102) were sown in protrays of 98 wells filled with coir pith on the same day and watered. The beds of 28m × 1.2m were prepared in the main seed production field. The well decomposed farm yard manure of one tonne was applied uniformly to all the beds. Later on, the black polythene mulch was put over the beds with drippers were laid inside. The 21 day old healthy seedlings of both parents were transplanted to main field on the same day at the spacing of 4 × 6 feet in the block system by maintaining the planting ratio of 3:1.

In the experiment, fertilizer application was followed on the basis of package of practice recommended by the University of Agricultural Sciences, Raichur and Dharwad**.** The recommended dose of fertilizer to be applied per hectare is 50-100 kg. N, 40-60 kg P_2O_5 and 30-60 kg K_2O. Half the N and entire P & K should be applied before planting and the 25 kg of remaining nitrogen was applied as top dressing. The staking with bamboo stick was provided and the vines were trailed on the jute thread.

Crossing work was initiated during peak flowering from 55 days after sowing continuously for 15 days. Female flower buds which are likely to open on next day were selected in the evening hours (4 to 6 pm). The selected buds were covered with white coloured butter paper. Next day morning (8 to 10 am) optimum size male flowers were collected from the male parent. The pollen from male flowers was gently dusted on the stigma of female flower. The crossed female flower buds were covered with brown coloured pockets and the flower stalk was tied with coloured thread for identifying the crossed fruit.

Five plants from each plot was randomly selected and marked with label for taking various observations. The hybrid fruits from the female parent was harvested at 85-90 DAS, when the fruit colour turned to yellowish orange and the fruits were cut open longitudinally and the pulp along with seeds were scooped out and kept for fermentation overnight and the seeds were washed and dried under diffused sunlight until safer moisture level achieved. The various observations on growth and yield parameters were recorded at the time of harvest.

Seed Germination (%)

The standard germination test was carried out by following between paper method as per ISTA procedure. Hundred seeds in four replications were taken from each treatment and placed on germination paper uniformly. The roll towels were kept in a germination chamber maintained at 25 ± 2°C temperature and 90 ± 5 per cent relative humidity. Then the first count was taken on 4^{th} day and final count on 14^{th} day. The number of normal seedlings from each replication was counted and the mean germination was expressed in per cent (ISTA, 2013).

Seedling Vigour Index (SVI)

The seedling vigour index-I was calculated by employing the formula given by Abdul-Baki and Anderson, 1973.

SVI-I = Germination (%) x Total seedling length (cm)

RESULTS AND DISCUSSION

The results from the above experiment revealed that foliar application of boron and plant growth regulators significantly influenced the growth, hybrid seed yield and its attributing characters, economics and seed quality parameters of bitter gourd.

A remarkable increase in vine length (375.0 cm) was observed with foliar spray of boron @ 1g/l + GA_3 50 ppm compared to control (320.0 cm) (Table 1). This maximum vine length in combination of GA_3 with boron might be due to cell division, cell elongation and quicker multiplication of cells in the shoot apex. These osmotic driven responses under the influence of gibberellins might have been attributed to increase in photosynthetic activity, accelerated translocation and efficiency of utilizing photosynthetic products, thus resulting in increased cell elongation and rapid cell division in the growing portion. Similar effects were also reported by Hilli *et al*. (2010) in ridge gourd.

Generally yield depends on traits such as number of fruits per plant, fruit length, fruit diameter, fruit weight, number of seeds per fruit, seed weight per fruit and 100 seed weight. In the present study, significantly higher number of fruits (14.47), fruit length (25.8 cm), fruit diameter (7.2 cm), fruit weight (151.9 g), No. of seeds per fruit (24.7), seed weight (5.48 g) per fruit, 100 seed weight (22.32 g), hybrid seed yield (79.6 g) per plant and (497.3 kg) per hectare was recorded by the combined application of boron @ 1g/l + homobrassinolide @ 0.5 ml/l compared to control (13.60, 19.7 cm, 6.3 cm, 115.7 g, 22.6, 4.74 g, 20.93 g, 64.1 g/plant, 401.1 kg/ha) recorded significantly lowest parameters (Table 1).

This may be due to the action of Brassinosteroids, which play a regulatory role in early fruit development. It is worth noting that fruit development is a complex process and Brassinosteroids could cross-talk with other hormones such as auxins and GA_3 (Roghabadi and Pakkish, 2014) in sweet cherry. The increase in fruit length and diameter might be due to the fact that, Brassinosteroids stimulate cell elongation, cell division and differentiation that promote fruit growth (Kang

TABLE 1

Effect of boron and plant growth regulators on yield and its attributing parameters

Treatment	Vine length (cm)	Number of fruits per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Number of seeds per fruit	Seed weight per fruit (g)	100 seed weight (g)	Hybrid seed yield (g/plant)	Hybrid seed yield (kg/ha)
T_1	320.0	13.60	19.7	6.3	115.7	22.6	4.74	20.93	64.1	401.1
T_2	328.7	13.73	21.7	6.4	121.6	22.7	4.83	21.26	66.2	413.9
T_3	375.0	14.43	24.5	7.1	141.1	24.5	5.43	22.17	78.2	488.8
T_4	364.0	14.07	23.2	7.0	139.3	24.4	5.25	21.62	73.5	459.4
T_5	344.0	13.90	23.2	6.8	137.9	23.3	4.97	21.38	69.3	433.0
T_6	368.7	14.47	25.8	7.2	151.9	24.7	5.48	22.32	79.6	497.3
T_7	334.0	13.80	23.1	6.6	131.6	22.8	4.89	21.31	67.1	419.4
Mean	347.8	14.00	23.0	6.8	134.2	23.6	5.08	21.57	71.1	444.7
S. Em±	4.2	0.11	0.7	0.1	5.1	0.4	0.11	0.28	1.4	8.6
C.D at 5%	12.9	0.34	2.3	0.3	16.1	1.2	0.35	0.89	4.3	24.5

and Guo, 2011). Due to increase in fruit length and diameter consequently the fruit weight and number of seeds were automatically increased. Roghabadi and Pakkish (2014) reported that trees sprayed with brassinosteroid 0.75 mgl^{-1} at swollen bud stage recorded the biggest yield in terms of fruit weight in sweet cherry.

The increase in seed yield might be due to foliar application of plant growth regulators along with boron which might have brought certain metabolic changes during fruit and seed development there by increased the food reserve accumulation and resulted in higher seed yield. This overall increase in seed yield could be attributed to the capacity of brassinolide and epibrassinolde to increase the seed number per fruit and fruit size by stimulating the translocation of photosynthates into seeds. Brassinosteroids activate proton pump, thereby get involved in cell division and enlargement besides, associated with increased metabolic processes like photosynthesis and protein synthesis. Sumathi *et al*. (2017) in pigeon pea reported that 0.1 ppm of homobrassinolide was effective in increase the number of seeds per pod and 100 seed weight. Homobrassinolide (HBR) stimulate plant metabolism and growth, leading to an increase in number of ears per plant, grains per ear and grain size in wheat. Prakash *et al*. (2008) reported that 1.0 ppm of homobrassinolide improved yield in sesame.

Economics worked out from the present study indicated that foliar application of boron @ 1g/l + homobrassiolide @ 0.5 ml/ 1 recorded highest monetary returns in terms of gross returns (Rs.5,47,030 ha^{-1}), net returns (Rs.3,69,862 ha^{-1}) and BC ratio (3.08). While, lowest returns was obtained from control (Rs.4,41,210 ha^{-1}, Rs.2,65,890 ha^{-1} and 2.51, respectively) (Table 2).

The higher B:C ratio might be due to increased seed yield and this might be due to foliar application of boron and plant growth regulator which were found to be more effective in increasing the yield attributing characters by increasing higher source to sink ratio which ultimately results in the overall seed yield and in turn resulted in enhanced gross returns and net returns in bitter gourd hybrid seed production.

After the harvest of crop, seeds were extracted from the fruit and were analyzed for various quality parameters. Growth regulators spray along with boron, which had a significant influence on the seed quality parameters over control. The seeds extracted from the fruits which received boron @ 1g/l + homobrassinolide (HBR) @ 0.5 ml/l noticed

TABLE 2

Effect of boron and plant growth regulators on cost of cultivation, gross returns, net returns and benefit cost ratio of hybrid seed production in bitter gourd

Treatment	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	Benefit cost ratio
T_1	175763	441210	265,890	2.51
T_2	176158	455290	279,597	2.58
T_3	179834	537680	358,442	2.99
T_4	176393	505340	329,495	2.86
T_5	176870	476300	299,929	2.69
T_6	177783	547030	369,862	3.08
T_7	177179	461340	284,635	2.60
Mean	177140	489170	312,550	2.76
S. Em±	-	-	691	0.004
C.D at 5%	-	-	2152	0.012

significantly higher seed germination (99.3 %), shoot length (24.8 cm), root length (16.9 cm), seedling dry weight (1052.3 mg), seedling vigour index- I (4141) and dehydrogenase enzyme activity of (0.939 OD value) (Table 3) and the control recorded significantly lowest of all above parameters (94.0 %, 21.8 cm, 13.1 cm, 843.8 mg, 3281 and 0.624 OD value) (Table 3), respectively.

The Homobrassinolide (HBR) had beneficial effect on seed germination by increasing the amylase activity, photosynthesis, translocation, membrane stability and stress tolerance. Probably, the increase in water content of the HBR-treated seeds is an act of the hormone on the proton pump of the cell wall facilitating its loosening, thus, favouring the cellular elongation and result in better germination. Brassinosteroids (BS) enhances shoot and root growth, cell elongation, vascular differentiation, xylem formation in epicotyls, and also in the regulation of expression of several genes involved in xylem development. Similar findings were noticed by who observed that 0.01 and 0.05 ppm homobrassinolide enhances the seedling growth in wheat.

The positive influence of growth regulators and boron was noticed on seed germination, shoot and root parameters consequently their significant increase on seedling dry weight and seedling vigour index- I. This increase could be due to adequate supply of food reserves for the embryo growth and synthesis of hydrolytic enzymes which in turn affects the seed germination, seedling emergence ultimately seedling vigour. Brassinosteroids found to be cross talk with GA_3 during germination involved in the activation of hydrolytic enzymes which could breakdown the macromolecules into simple sugars makes them available to growing tip of seedling for uniform growth and establishment. Similar effects were reported by Sirhindi *et al.* (2009) in mustard and Srivastava *et al.* (2011) in mung bean due to application of growth regulators.

On the basis of findings of present investigation, following conclusions have been drawn. Foliar application of boron @ 1g/l + homobrassinolide @ 0.5 ml/l was found significantly superior in terms of hybrid seed yield and quality parameters and significantly higher monetary returns (3.08) can be realized by spraying boron @ 1g/l + homobrassinolide @ 0.5 ml/l during hybrid seed production.

TABLE 3

Effect of boron and plant growth regulators on seed quality parameters of bitter gourd

Treatment	Seed germination (%)	Shoot length (cm)	Root length (cm)	Seedling dry weight (mg)	Seedling vigour index- I	Dehydrogenase enzyme activity (OD Value)
T_1	94.0 (75.8)	21.8	13.1	843.8	3281	0.624
T_2	95.3 (77.4)	22.2	13.9	873.8	3450	0.648
T_3	98.3 (82.3)	24.5	16.5	964.3	4030	0.837
T_4	96.8 (79.6)	23.2	16.2	927.5	3814	0.760
T_5	96.0 (78.5)	23.1	14.9	894.0	3648	0.700
T_6	99.3 (85.0)	24.8	16.9	1052.3	4141	0.939
T_7	95.5 (77.8)	22.4	14.5	877.3	3524	0.669
Mean	96.4 (79.1)	23.1	15.1	919.0	3692	0.740
S. Em±	0.9	0.6	1.0	23.6	116	0.016
C.D at 1%	2.9	1.8	3.1	70.0	344	0.048

Note: Figures in the parenthesis indicates arc sign transformed values

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